Soft Pneumatic Manipulator with Stiffness Tuning Capability

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Introduction

Objective
- Design and fabricate a soft robot with manipulation and stiffness tuning capability that is controllable via pneumatics
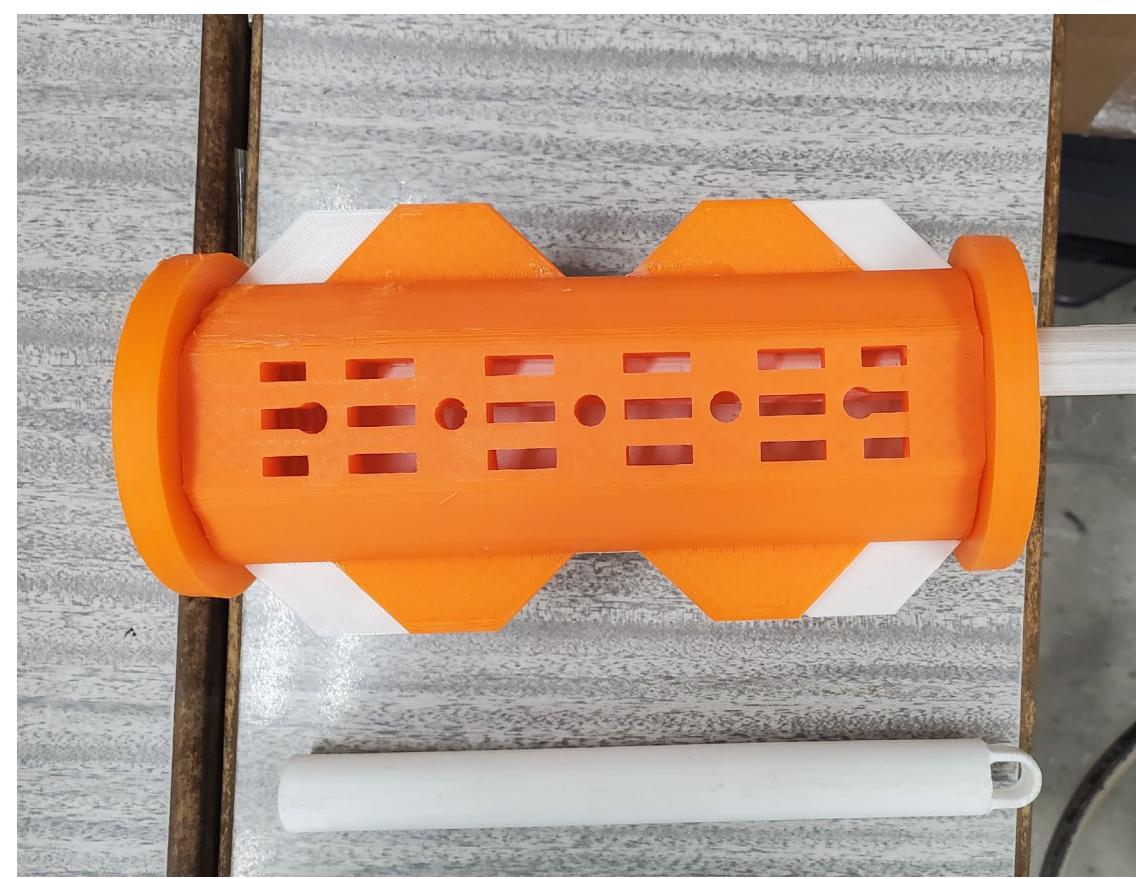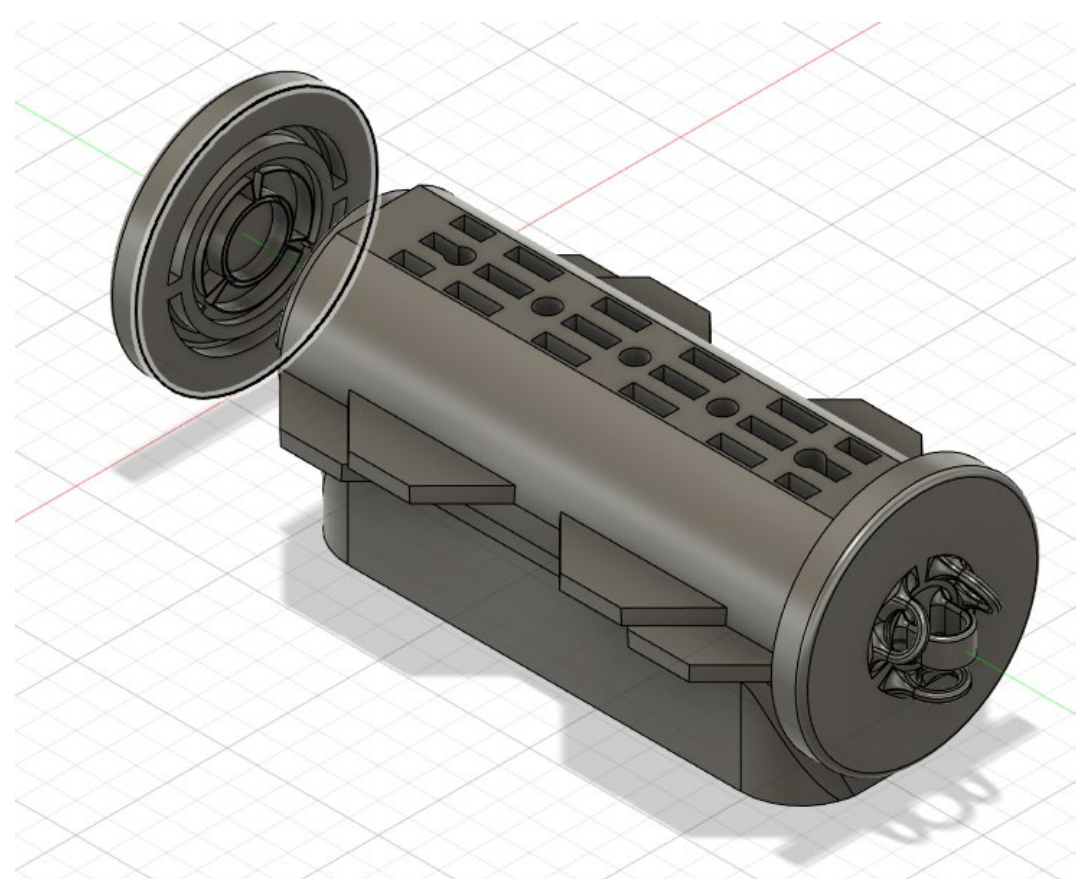
Challenges
- High compliance with large payload causes deformation
- Precise control of arm via pneumatics
- Wide range of stiffness possibilities to control around

Fabrication

3D Printed Mold
- Mold model for robotic arm designed in CAD
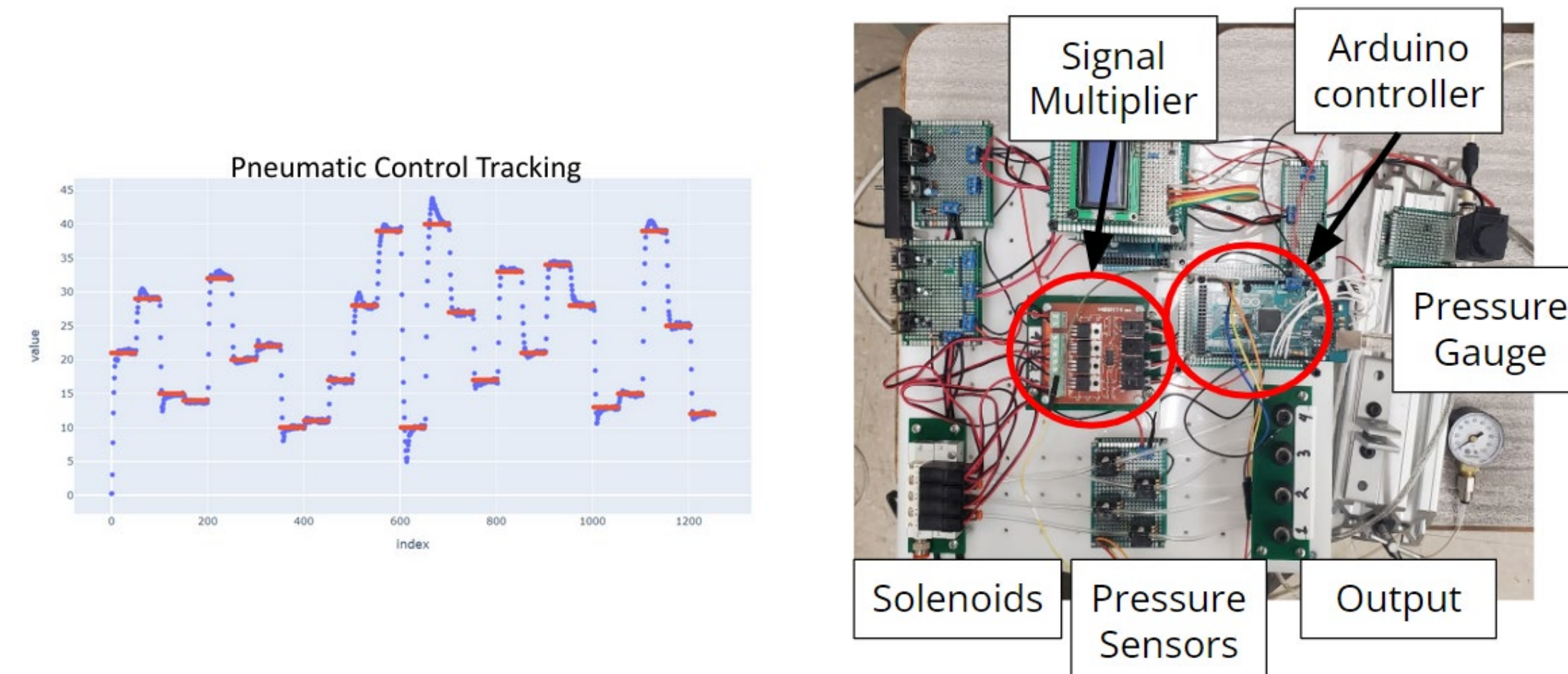- Mold parts 3D printed from lab printer using PLA and assembled for casting

Silicone Casted Arm
- Manipulator casted from Dragonskin 20™ silicone
- Silicone caps made for sealing air chambers and connecting pneumatic tubing

Pneumatic Control

- PID control of individual chambers on manipulator
- Operating pressure of up to 120KPA

Pneumatic Control Tracking

Signal Multiplier · Arduino controller · Pressure Gauge · Solenoids · Pressure Sensors · Output
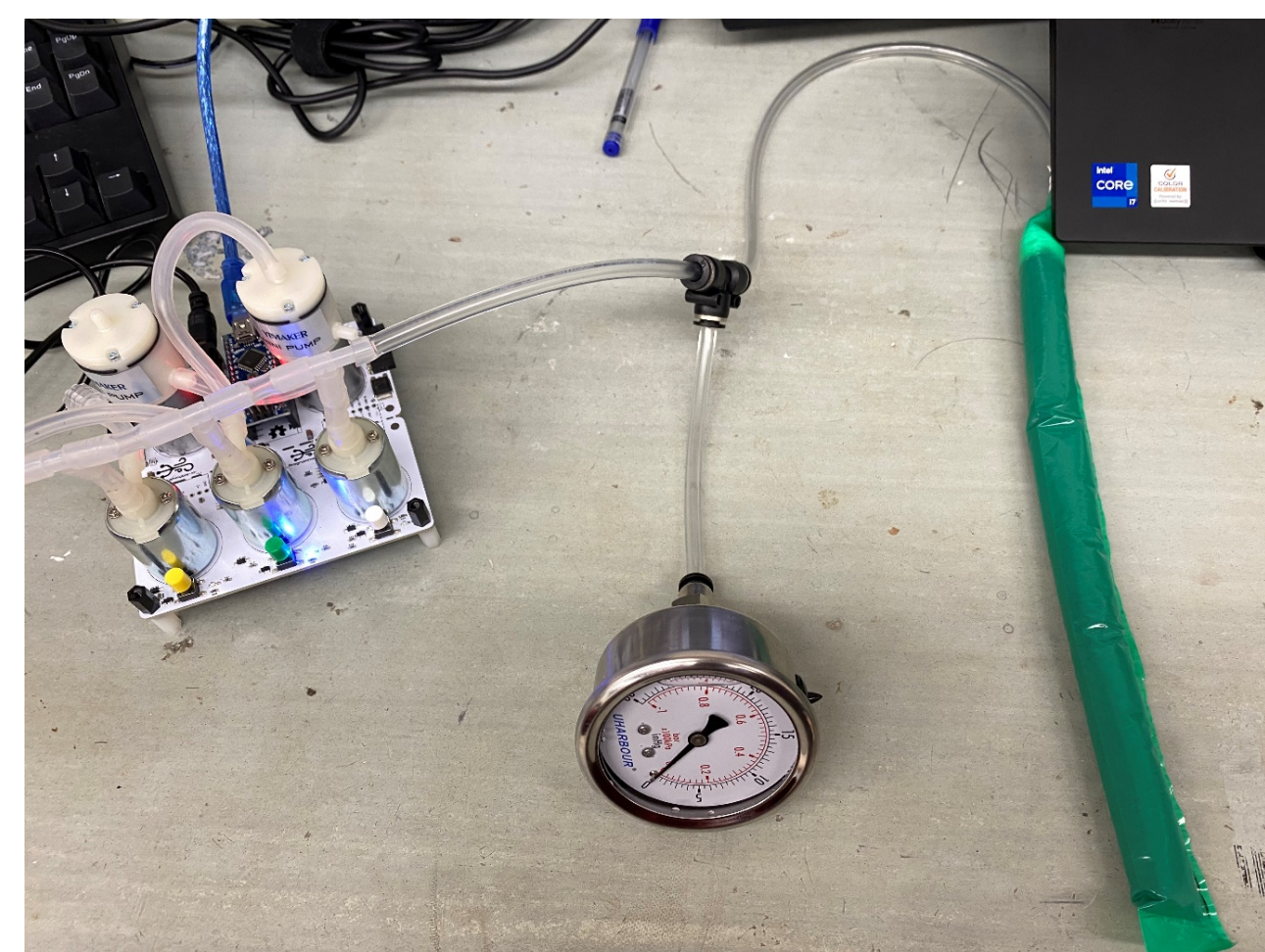
Stiffness Tuning

- Variable stiffness enables the soft robot to take advantage of providing stable end-effector positioning, storing energy within the system to rapidly accelerate, and handle larger payloads
- Particle jamming mechanism with multiple variations and combinations of particles tested.

Vacuumed foil tube · Pneumatic chamber · Particle · Seed Beads · Pasticle Balls · Coffee Powder
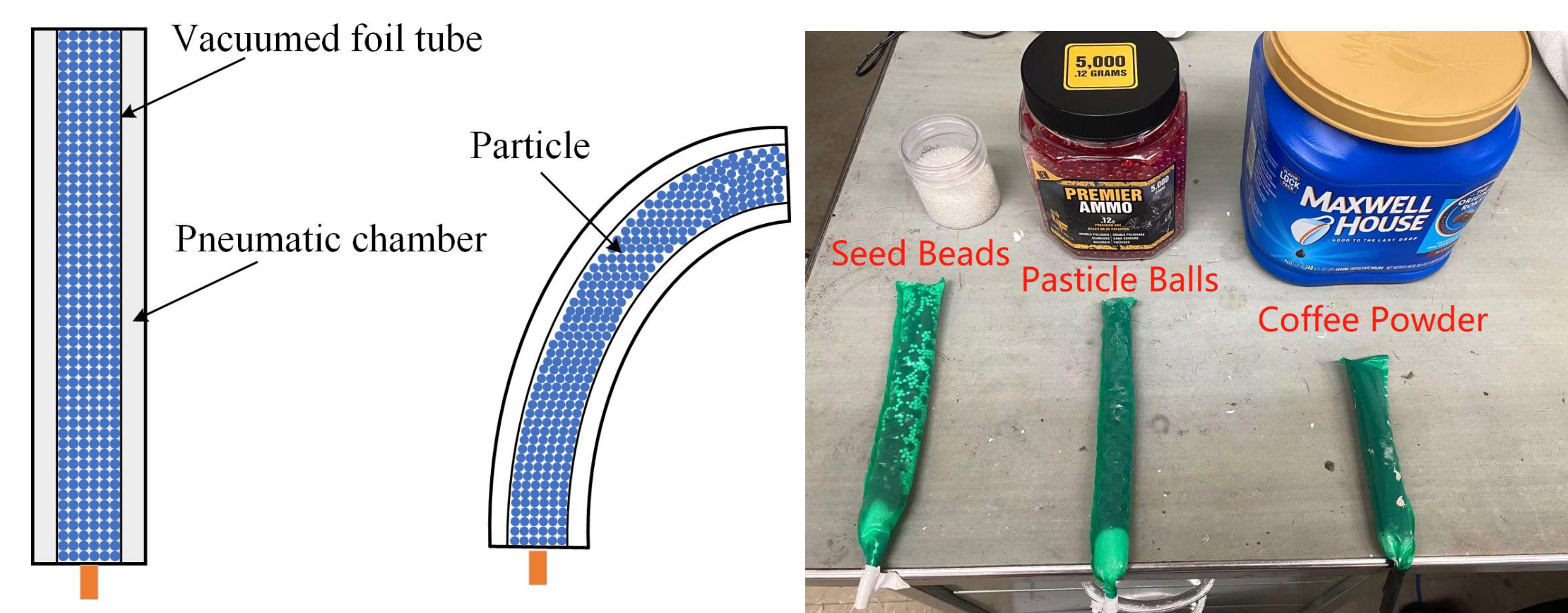
- Independent control by small vacuum pump to create negative pressure and jam particles increasing stiffness

- Coordinated control of actuation and stiffness-tuning continues to be a key focus.

Results

- Stiffness tuning reduces the effects of external disturbances such as payload
- Bending force sufficient to lift target weight (apple)

With Stiffness Tuning · Without Stiffness Tuning
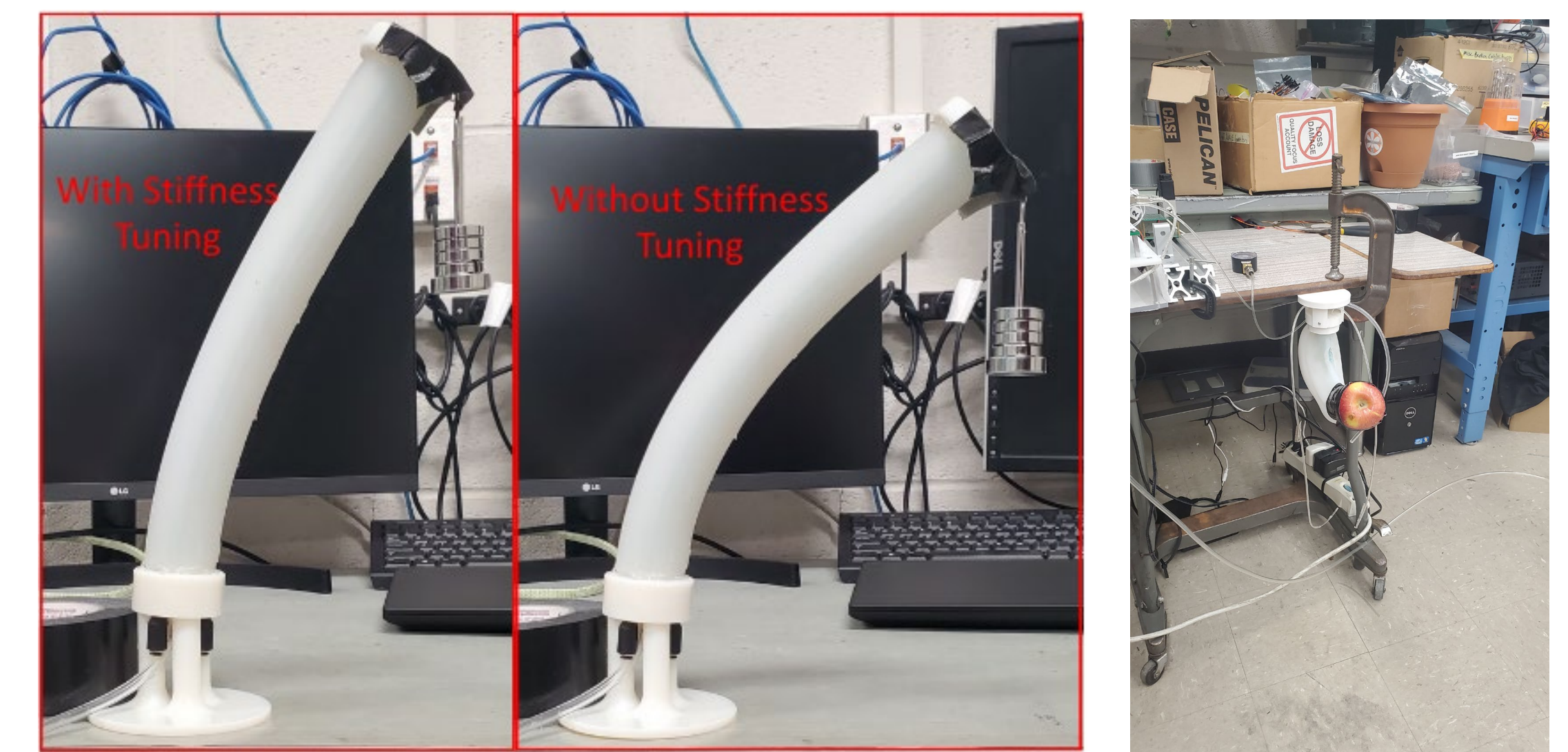
- Capable of achieving 90° bending angle
- Multiple chambers can be inflated in conjunction to control the direction of bending
- All chambers can be inflated to create elongation of the manipulator

Future Work

- Add additional segments for larger and more accessible workspace
- Implement higher level control and path planning algorithms to accomplish tasks utilizing stiffness tuning

Acknowledgements